Priority Based Lora – Loss Differentiate Rate Adaptation Scheme For Vehicle To Vehicle Safety Communication

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Abstract-*The vehicle to vehicle (V2V) communication supports the safety applications and has the potential to identify the road crash issues. The rate adaptation approach is used to meet the severe delay and reliability requirements under dynamic networks. The rate adaptation approach determines the optimal data rate according to the channel conditions. However, existing rate adaptation approaches cannot be applied directly on the V2V communication in highway scenarios, which reveals stringent packet losses and lots of dynamics. Furthermore, packet transmission suffers from channel fading in the PHY-layer as well as interference in the MAC-layer. To address these issues, a LOss Differentiation Rate Adaptation (LORA) scheme is proposed that differentiates the fading losses from the interference losses and estimates the average packet loss rate for each vehicle. A method is proposed for priority based safety message transmission which reduces the congestion in the network and high priority emergency message are easily transmitted without any delay*.

Keywords-Vehicle-to-Vehicle Safety Communication, Rate Adaptation, Channel Fading, VANET.

I. INTRODUCTION

Traffic accidents have been considered as one of the top five causes responsible for human death. The Intelligent Transportation System (ITS) plays an important role in vehicular network. V2V communication provides critical safety related applications, such as cooperative forward collision warning, emergency electronic brake lights, lane change assistance, blind spot warning etc.,

V2V safety communications require exchanging safety related messages among neighboring vehicles quickly and reliably. The single-hop broadcast has been a fundamental mechanism to handle the highly dynamic topology and meet the delay requirement [4]. The single-hop broadcast is able to meet the delay requirements, but may fail to provide reliability guarantee [6]. This is due to the ad hoc nature of V2V broadcast, constantly changing topology of vehicular network, high density traffic on the highway, etc.,

Rate adaptation (RA) is an effective method to achieve better system performance in dynamic mobile networks. However, RA solutions cannot be directly applied to V2V safety communications. The main challenge in V2V communication is the channel condition estimation in an open-loop manner. In high way scenario, data transmission may suffer from fading in the PHY-layer and non-trivial collisions in the MAC-layer.

The LOss Differentiation Rate Adaptation (LORA) scheme is proposed to differentiate the interference losses from fading losses and find the best data rate while considering channel conditions. LORA using some information such as distance from neighboring vehicles, traffic density and wireless connection information to efficiently estimate the data rates of each vehicles. The design goal of LORA is

- To minimize the average Packet Loss Ratio (PLR) with safety range rather than to maximize the throughput. This is because the reliability is much more critical in safety communication.
- Meanwhile, the safety messages are sent periodically in a low frequency and do not need high throughput.
- Under some emergency conditions, the network require more reliable and fast transmission to inform the neighboring vehicles.
- The priority based ordering of messages help the emergency message transmission without any delay.

The rest of the paper is organized as follows. Section II discusses related work. Section III introduces system architecture. Section IV presents modules of my paper. Section V describes Results and discussion.

II. RELATED WORKS

Oscar Punal, et al.., have described about RFRA: Random Forests Rate Adaptation for vehicular networks.Rate adaptation in vehicular networks is known to be more challenging than in WLANs due to the high mobility of stations. Nevertheless, vehicular networks are subject to certain recurring patterns particularly if stations communicate to roadside units. This has led to the proposal of learning based rate adaptation schemes which are trained for a certain propagation environment. In general, these schemes outperform other approaches at the price of being specific for a particular environment. RFRA presents, a novel rate adaptation scheme for vehicular networks. It is based on the machine-learning algorithm Random Forests which is known to be superior to most other learning approaches.

F. Martelli, et al.., have described about A Measurement-based Study of Beaconing Performance in IEEE 802.11p Vehicular Networks. Active safety applications for vehicular networks aims at improving safety conditions on the road by raising the level of "situation awareness" onboard vehicles. Situation awareness is achieved through exchange of beacons reporting positional and kinematic data. Two important performance parameters influence the level of situation awareness available to the active safety application: the beacon (packet) delivery rate (PDR), and the packet inter-reception (PIR) time. While measurement-based evaluations of the former metric recently appeared in the literature, the latter metric has not been studied so far.

Ce Liu, et al.., have described about GeRA: Generic rate adaptation for vehicular networks. Vehicular networks arc novel wireless networks particularly for inter-vehicle communications. In vehicular networks, the current rate adaptation algorithms are not applicable to the new situations. We propose a novel hybrid rate adapt it lion scheme named as GeRA (Generic Rate Adaptation). The key idea of this scheme is to make use of both context information and signal strength information to estimate current channel condition in a much more efficient and accurate way. GeRA dynamically and adaptively switches the rate selection resources between our well-designed context information empirical model and SNR prediction model according the current situation to achieve the high mobility, density and variation.

Pravin Shankar, et al.., have described about CARS: Context-aware rate selection for vehicular networks. Traffic querying, road sensing and mobile content delivery are emerging application domains for vehicular networks whose performance depends on the throughput these networks can sustain. Rate adaptation is one of the key mechanisms at the link layer that determine this performance. Rate adaptation in vehicular networks faces the following key challenges: (1) due to the rapid variations of the link quality caused by fading and mobility at vehicular speeds, the transmission rate must adapt fast in order to be effective, (2) during infrequent and busty transmission, the rate adaptation scheme must be able to estimate the link quality with few or no packets transmitted in the estimation window, (3) the rate adaptation scheme must distinguish losses due to environment from those due to hidden-station induced collision.

III. SYSTEM OVERVIEW

In this section discuss about priority based safety message transmission using LORA.

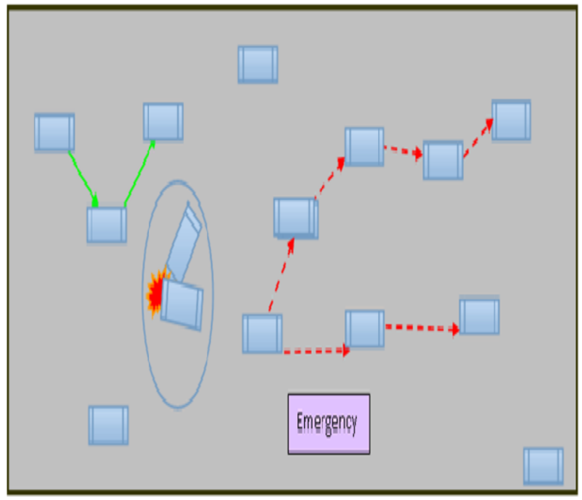

Fig.1: Priority Based Safety Message Transmission

Fig.1 presents the architecture of priority based safety message transmission with the vehicles in blue color that green arrows are specifying V2V communication. While vehicle crashes, immediately LORA method transmits the message based on priority that reduces the congestion in the network and high priority emergency message are easily transmitted without any delay that specify using red arrows.

IV. MODULES

A. Packet Loss Ratio (PLR) Estimation

In the highway scenario, data transmissions suffer a lot from fading and shadowing in the PHY-layer as well as non-trivial collisions in the MAC-layer. PLR caused by channel fading according to distances among all neighboring vehicles. The tagged node estimates the average PLR to reduce the packet loss in VANET communication.

Each vehicle can obtain its own location from the GPS device. The position of neighboring vehicles are exchanged via V2V communications. For each vehicle, LORA extracts the traffic density, distance from neighboring vehicles and wireless connection information. Using these information, LORA can efficiently estimate and differentiate packet losses due to different reasons. Finally, LORA selects the best data rate according to both the interference losses and fading losses to guarantee the reliability for V2V safety communications.

The PLR_{AVG} is the ratio of the number of lost packets to the total number of sending packets within the safety range of the tagged node. It is calculated by

$$PLR_{AVG} = \frac{1}{n} \sum_{k=1}^{n} \frac{L}{R}$$

Where n is the number of vehicles within the safety range of the tagged node, L represents the lost packets and R represents the received packets.

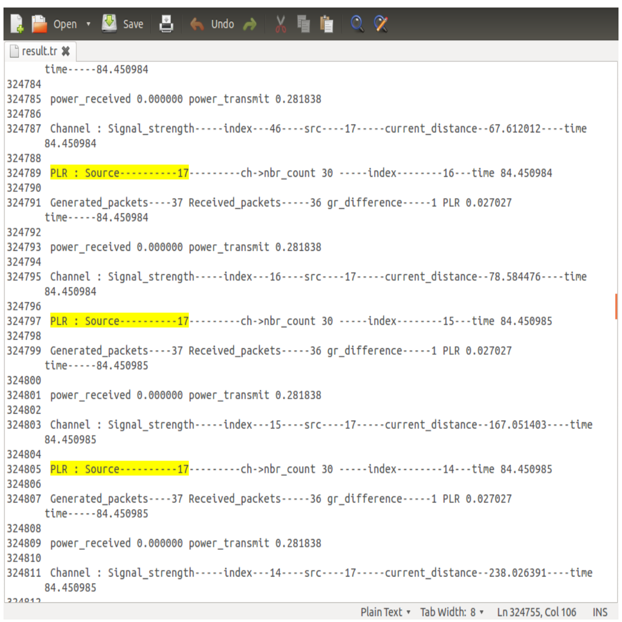

Fig.2: Packet Loss Ratio

Fig.2 shows the Packet Loss Ratio. When the hello message is received by neighbor nodes, they calculate the Packet Lose Ratio (PLR) based on generated packet counts and received packet counts.

B. Channel Condition Estimation

Rate adaption solutions cannot be directly applied to V2V safety communications. First, it is challenging to accurately estimate channel conditions in an open-loop manner. The low data rates can tolerate poor channel conditions, yet introduce severe interferences. The high data rates can reduce the collision probability but require better channel conditions to sustain effective transmissions. The vehicle periodically broadcast the message to continuously obtain the distance between neighbor vehicles and also estimate the channel condition. The distance between the vehicles are frequently changed over time due to moving. When a neighbor vehicle crosses the source node, the neighbor vehicle remains stationary and keep a certain distance from the source node for several minutes.

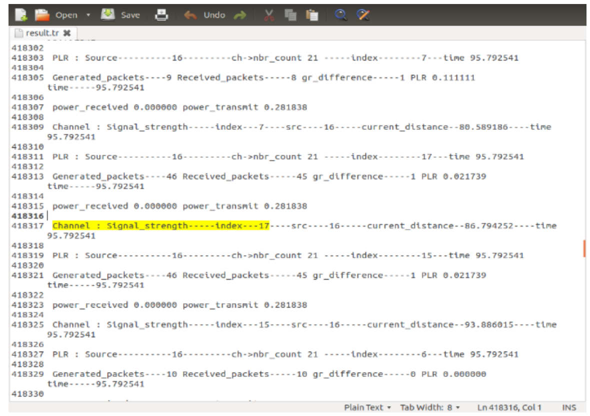

Fig.3: Channel Condition Estimation

Fig.3 shows Estimation of Channel Condition by evaluating the signal strength with distance over time. During movement of the node, the received signal strength changes with an average variation can be noticed. When the node moves to edge of communication range, signal quality will be reduced.

C. Rate Selection Algorithm

The data rates of each vehicle is estimated with considering channel condition and wireless transmission collision. The V2V safety communication can be achieved by finding the best data node using LORA. LORA selects the best data rate depending on the interference losses and fading losses. PLR due to interference can be calculated with an estimated average PLR and the PLR caused by channel fading. The rate selection algorithm considers both PLR values due to interference channel fading which is not accurate.

Estimation between two nodes are

i. Channel estimation = current distance / maximum distance
ii. Interference estimation = neighbour count / maximum neighbour count
iii. Add_value = Channel estimation + Interference estimation
iv. Channel PLR percentage in PLR average = (Channel estimation / Add_value) * PLR
v. Interference PLR percentage in PLR average = (Interference estimation / Add_value) * PLR

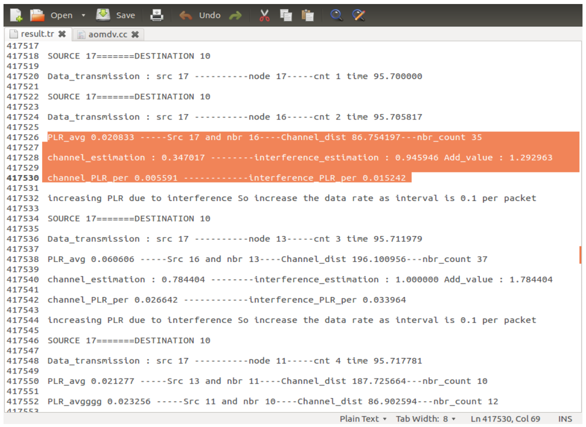

Fig.4: Rate Selection Algorithm

Fig. 4 shows the calculation of rate selection algorithm by finding PLR values for both interference and channel fading.When PLR gets larger due to channel fading than interference, low data rate is chosen to tolerate the bad channel quality. The selected data rate tendsto be higher with increasing PLR due to interference. Hence, higher data rate can significantly shorten the packet transmission duration and rising the data rate level which reduce the collision probability greatly.

D. Priority Based Safety Message Transmission

Every vehicle broadcast the beacon messages to its neighbor vehicles. Beacons contain normal periodic status such as vehicle speed, velocity, id location. All vehicles are responsible to broadcast the emergency messages. The LORA improves the reliability and performance of dynamic network with priority based transmission. The emergency messages are sent to its neighbors based on its priority. The message having high priority is sent early to its neighbor vehicles. The priority based transmission minimize the network congestion and emergency messages are easily transmitted without delay.

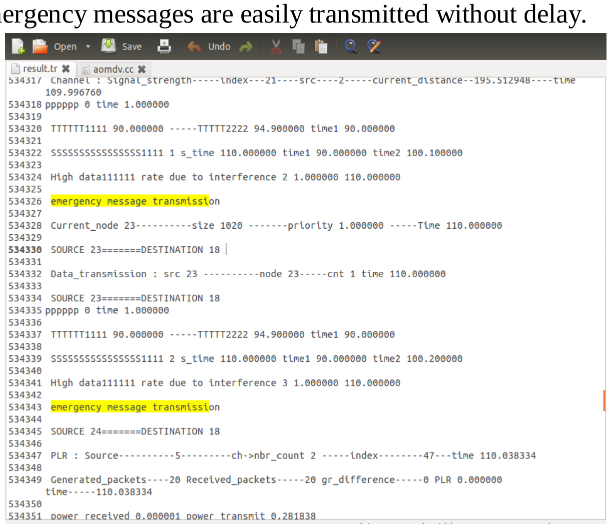

Fig.5:Priority Based Safety Message Transmission

Fig.5 shows Priority Based Safety Message Transmission. If the priority of message is low, it sends the data fully in the particular event. If the priority of message is high, it splits the data and sends in the particular event.

V. RESULTS AND DISCUSSION

The performance of Loss Differentiate Rate Adaptation scheme was analyzed using network simulator2. The experimental model was built with 48 nodes distributed randomly on square surface of 600 x 600 m^2. The Enhanced LOss differentiation Rate Adaptation (E-LORA) scheme is proposed for V2V safety communication in highway scenario. A hybrid system model is established by combining highway scenario, PHY-layer propagation, MAC-layer back off and MAC-layer interference models together. Both the average packet loss rate and the channel condition estimation algorithms are designed based on the proposed model. LORA adapts the data rate according to the environment dynamics rapidly and appropriately.

Performances And Evaluation

A. Simulation Model

SIMULATOR	Network Simulator
INTERFACE TYPE	Phy/WirelessPhy
CHANNEL TYPE	Channel/Wireless Channel
QUEUE TYPE	Droptail/Priority Queue
QUEUE LENGTH	50 Packets
ANTENNA TYPE	Omni Antenna
PROPAGATION TYPE	TwoRayGround
NETWORK AREA	552*552
ROUTING PROTOCOLS	LORA
SIMULATION TIME	140s
NUMBER OF NODES	50,60,70
TRANSMISSION RANGE	250m
MAC LAYER PROTOCOL	IEEE 802.11
SPEED	20m/s
TRANSPORT AGENT	UDP
APPLICATION AGENT	CBR

(i) Network Congestion is reduced

Network congestion occurs when a network node is carrying more data than it can handle. Network protocols that use aggressive retransmissions to compensate for packet loss due to congestion, even after the initial load has been reduced to a level that would not normally have induced network congestion. Priority schemes help to alleviate the effects of congestion in the network.

(ii) Delay performance is overcome

The delay specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. The transmission delay is caused by the data-rate of the link. Emergency messages can be transmitted without delay using priority based arrangement of data.

(iii) Reliable packet delivery is achieve

The transmitted packets reach the exact destination even during dynamic topology changing conditions. Reliability improves the packet delivery rates without retransmitting the same packets.
Comparative Graph

Control Overhead

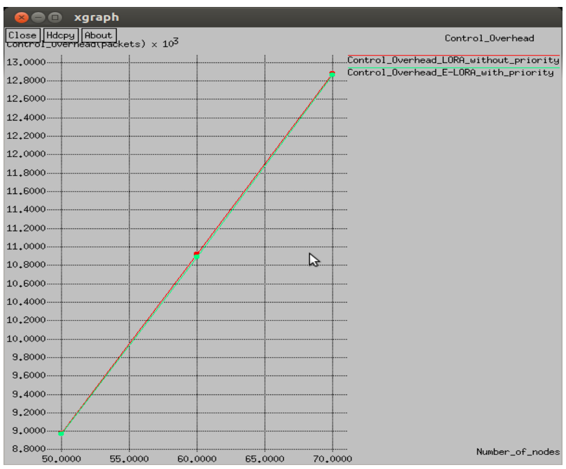

Fig.6 shows the graph on Control Overhead of proposed and enhanced method. Here, the x-axis represents the Number of nodes and y-axis represents the Control Overhead. When number of nodes are increased, E-LORA method achieves reduced control overhead when compared to LORA method.

Packet Delivery Ratio

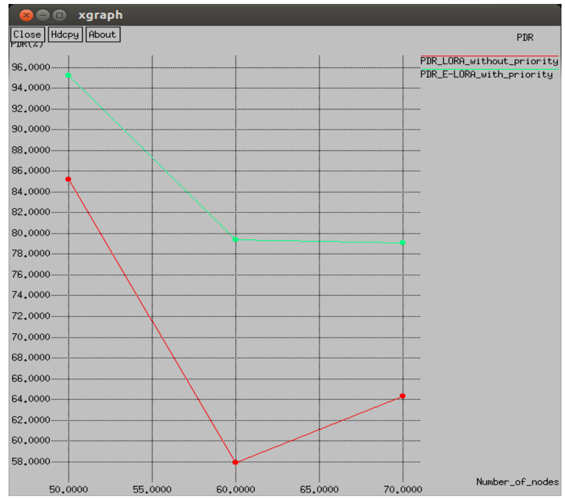

Fig.7 shows the graph on Packet Delivery Ratio of proposed and enhanced method. The x-axis represents the Number of nodes and y-axis represents the Packet Delivery Ratio. Here, the Packet Delivery Ratio is increased by E-LORA when compared to LORA method.

Delay Ratio

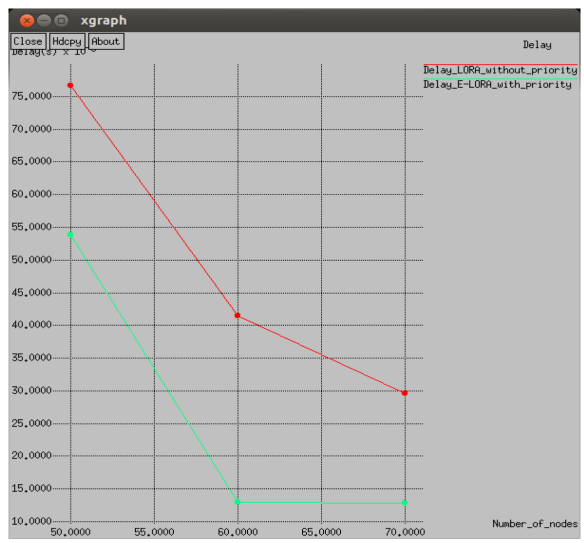

Fig.8 shows the graph on Delay Ratio in proposed and enhanced method. The x-axis represents the Number of nodes and y-axis represents the Delay Ratio. Here, the Delay Ratio is reduced by E-LORA when compared to LORA method.

VI. CONCLUSION

This research work proposes an Enhanced LOss differentiation Rate Adaptation (E-LORA) algorithm for V2V safety communication in highway scenario. The design challenges in the safety message broadcast environment are addressed using analytical models. The design goal of LORA is to minimize the average PLR with safety range rather than to maximize the throughput. LORA selects the optimal data rate considering both losses due to channel fading in PHY layer and interference in MAC layer. The priority based safety message transmission supports the emergency message transmission without any delay and reduces the congestion in the network. The performance of priority based LORA scheme is more efficient than other rate adaptation schemes in terms of reliability, throughput and delay.

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